Al-Cu-Mg ALLOY EXCELLENT IN TOUGHNESS AND ITS PRODUCTION

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Abstract

PURPOSE:To produce an Al-Cu-Mg alloy excellent in toughness, contg. specified amounts of Cu, Mg, Fe, Si Cr or the like, by executing hot rolling or the like after continuous casting and specifying the cooling rate at the time of solidification.
CONSTITUTION:An Al alloy having a compsn. contg., by weight, 2 to 7% Cu, 0.2 to 2.5% Mg, 0=5 and R>=7.5 ([Fe]+[Si])+2, where [Fe] and [Si] denote the contents (%) of Fe and Si in the Al alloy.

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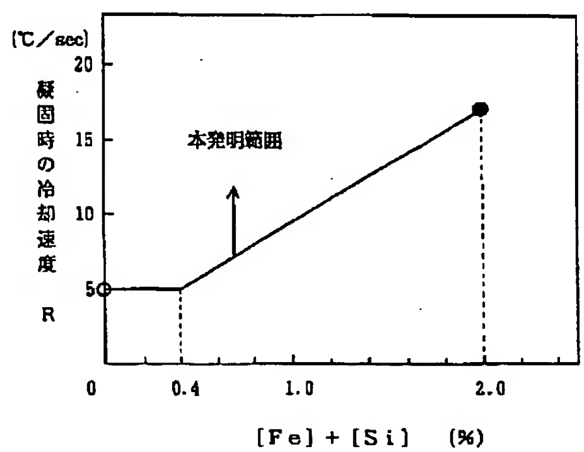
(54)【発明の名称】　靭性に優れたＡｌ－Ｃｕ－Ｍｇ系合金及びその製造方法

(57)【要約】

【目的】　航空機，鉄道車両，スポーツ用品などにおいて高強度が要求される構造部材用として好適な高強度Ａｌ合金であって、しかも靭性に優れたＡｌ合金及びその製造方法を提供する。

【構成】　Ｃｕ：２～７％，Ｍｇ：０．２～２．５％，Ｆｅ：１．０％以下，Ｓｉ：１．０％以下、かつＣｒ，Ｍｎ，ＺｒおよびＴｉよりなる群から選択された１種以上を夫々Ｃｒ：０．０５～０．３％，Ｍｎ：０．０５～０．８％，Ｚｒ：０．０５～０．３％，Ｔｉ：０．０３～０．３％の範囲内で含有し、残部がＡｌと不可避不純物からなるＡｌ合金において、連続鋳造後熱間圧延を行うか、または熱間圧延及び冷間圧延を行うと共に熱処理を施して、Ｆｅ及びＳｉを含む不溶性化合物粒の最大長さを２μm以下、かつ体積分率を２．０％以下に制御されたＡｌ－Ｃｕ－Ｍｇ系合金を開示する。



【特許請求の範囲】

【請求項1】Ｃｕ：２～７％（重量％を意味する、特記しない限り以下同じ）

Ｍｇ：０．２～２．５％

Ｆｅ：１．０％以下（０％を含まない）

Ｓｉ：１．０％以下（０％を含まない）

の要件を満たし、かつＣｒ，Ｍｎ，ＺｒおよびＴｉよりなる群から選択された１種以上を夫々

Ｃｒ：０．０５～０．３％

Ｍｎ：０．０５～０．８％

Ｚｒ：０．０５～０．３％

Ｔｉ：０．０３～０．３％

の範囲内で含有し、残部がＡｌと不可避不純物からなるＡｌ合金において、連続鋳造後熱間圧延を行うか、または熱間圧延及び冷間圧延を行うと共に熱処理を施して、Ｆｅ及びＳｉを含む不溶性化合物粒の最大長さを２μｍ以下、かつ体積分率を２．０％以下に制御してなることを特徴とする靭性に優れたＡｌ－Ｃｕ－Ｍｇ系合金。

【請求項2】　請求項１記載のＡｌ－Ｃｕ－Ｍｇ系合金を製造するにあたり、凝固時の冷却速度Ｒが

Ｒ≧５で且つ

Ｒ≧７．５（［Ｆｅ］＋［Ｓｉ］）＋２

但し、Ｒ：凝固時の冷却速度（℃／ｓｅｃ）

［Ｆｅ］，［Ｓｉ］：Ａｌ合金中のＦｅ、Ｓｉの含有率（％）

を満足する条件で連続鋳造した後、該鋳片温度を熱間圧延温度以上に保持して熱間圧延することを特徴とする靭性に優れたＡｌ－Ｃｕ－Ｍｇ系合金の製造方法。

【請求項3】　連続鋳造された移動帯板を直ちに熱間圧延工程へ送る請求項２記載の製造方法。

【請求項4】　連続鋳造された鋳片を、熱間圧延温度に調整して熱間圧延工程へ送る請求項２に記載の製造方法。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、靭性に優れたＡｌ－Ｃｕ－Ｍｇ系合金及びその製造方法に関し、詳細には航空機，鉄道車両，スポーツ用品などにおいて高強度が要求される構造部材用として好適な高強度Ａｌ合金であって、しかも靭性に優れたＡｌ合金及びその製造方法に関するものである。

【０００２】

【従来の技術】代表的な高強度Ａｌ合金としては、Ａｌ－Ｃｕ－Ｍｇ系合金がジュラルミンの名で知られており、ＪＩＳ規格の２０１４合金，２０１７合金，２０２４合金等が開発されている。尚上記Ａｌ－Ｃｕ－Ｍｇ系合金の高強度特性は、時効硬化によって得られるものであり、これを製造するにあたっては、まずインゴットを鋳造し、必要に応じて均質化処理を行ない、高温で充分鍛造して鋳造組織を取り除き、更に溶体化処理の後焼き入れをして時効処理を施すという方法が一般的である。

【０００３】しかしながら前記Ａｌ－Ｃｕ－Ｍｇ系合金は靭性が低く、特に熱間・冷間加工終了後の板厚方向（ＳＴ方向）の靭性が、加工方向（Ｌ方向）や幅方向（ＬＬ方向）に比べて、大幅に低いという問題を有している。これは合金中の不溶性化合物が加工方向に伸延されて連なり、鋭い切欠きとして働くことに起因している。尚上記不溶性化合物とは、Ａｌ精錬時に残存するＦｅやＳｉなどの不純物を含有する化合物であって、均質化処理や溶体化処理における処理温度を高くしても合金中に固溶せず粒状に晶出する化合物である。

【０００４】この様なＡｌ－Ｃｕ－Ｍｇ系合金の靭性を改善する手段としては、前記不溶性化合物の原因となるＦｅやＳｉなどの不純物元素の含有量を極力制限する方法が考えられる。例えばＪＩＳ規格では前記２０１４合金のＦｅ量が０．７％以下、Ｓｉ量は０．５～１．２％に規定されているが、特開昭５５－４７３７１号公報には不純物であるＦｅを０．１５％以下、Ｓｉを０．１％以下に限定する方法が開示されている。しかしながら不可避不純物であるＦｅ及びＳｉの含有量を極力制限することは、即ち極めて純度の高いＡｌ地金を必要とするものであり、コスト高となって実用性に乏しい。

【０００５】

【発明が解決しようとする課題】本発明は上記事情に着目してなされたものであって、不可避不純物であるＦｅやＳｉの含有量は従来と同程度であっても、製造方法を改善することにより圧延加工後のＳＴ方向においても靭性に優れたＡｌ－Ｃｕ－Ｍｇ系合金及びその製造方法を提供しようとするものである。

【０００６】

【課題を解決するための手段】上記課題を解決することのできた本発明に係るＡｌ－Ｃｕ－Ｍｇ系合金とは、

Ｃｕ：２～７％

Ｍｇ：０．２～２．５％

Ｆｅ：１．０％以下（０％を含まない）

Ｓｉ：１．０％以下（０％を含まない）

の要件を満たし、かつＣｒ，Ｍｎ，ＺｒおよびＴｉよりなる群から選択された１種以上を夫々

Ｃｒ：０．０５～０．３％

Ｍｎ：０．０５～０．８％

Ｚｒ：０．０５～０．３％

Ｔｉ：０．０３～０．３％

の範囲内で含有し、残部がＡｌと不可避不純物からなるＡｌ合金において、連続鋳造後熱間圧延を行うか、または熱間圧延及び冷間圧延を行うと共に熱処理を施して、Ｆｅ及びＳｉを含む不溶性化合物粒の最大長さを２μｍ以下、かつ体積分率を２．０％以下に制御してなることを要旨とするものである。

【０００７】そして上記Ａｌ－Ｃｕ－Ｍｇ系合金を製造する為の好適手段の一つとして、本発明は凝固時の冷却

速度Rが

R≧5……（1）

R≧7．5（［Fe］＋［Si］）＋2……（2）

但し、R：凝固時の冷却速度（℃／sec）

［Fe］，［Si］：Al合金中のFe、Siの含有率（%）

を満足する条件で連続鋳造した後、該鋳片を熱間圧延温度以上に保持された状態で直ちに、あるいは熱間圧延温度に調整してから熱間圧延する方法を提供するものである。尚上記条件式（1），（2）で示される推奨範囲は図1に示される如く、［Fe］＋［Si］の値が0．4%以下のときは（1）式によって、また［Fe］＋［Si］の値が0．4%超のときは（2）式によって規定されることを意味する。

【0008】

【作用】本発明者らはAl－Cu－Mg系合金の靭性を向上させるという課題について鋭意研究を重ねた結果、たとえFe及びSiをある程度含有したAl－Cu－Mg系合金であっても、連続鋳造によりFe及びSiを合金中に強制固溶させ、Fe及びSiを含む不溶性化合物粒の最大長さを2μm以下で、しかもその体積分率を2%以下に制御したものでは、強度を損なうことなく圧延加工後のST方向の靭性も向上させることができるとの知見を得た。さらに上記不溶性化合物粒の最大長さ及び体積分率を制御するには、連続鋳造過程における凝固時の冷却速度を一定条件内に制御してFe及びSiを合金中に強制固溶することが最良の方法であることをつきとめ、本発明を完成させた。まず本発明に係る成分組成の限定理由を以下に述べる。

【0009】Cu：2～7%

Mg：0．2～2．5%

Cu及びMgは、Al_2CuMgという1μm以下の微細な析出物を形成し、強度の向上に大きく寄与する元素である。Cu量が2%未満またはMg量が0．2%未満では充分な強度が得られず、一方Cu量が7%を超えるか又はMg量が2．5%を超えると、Fe及びSiを含有する不溶性化合物粒の最大長さが2μmを超えて粗大な晶出物となり、靭性を低下させる。従ってCu量は2～7%かつMg量は0．2～2．5%であることが必要である。

【0010】尚Cuの下限としては、より好ましくは2．5%以上、更に好ましくは3．5%以上、一方上限は好ましくは6．5%以下、更に好ましくは5．5%以下である。またMgの下限としては、より好ましくは0．5%以上、更に好ましくは1．0%以上、一方上限は好ましくは2．0%以下、更に好ましくは1．7%以下である。

【0011】Cr：0．05～0．3%

Mn：0．05～0．8%

Zr：0．05～0．3%

Ti：0．03～0．3%

本発明のAl合金においては、上記4種の金属元素のうち1種以上を上記の範囲内で含有させることにより、Al合金の結晶粒を微細化し靭性を向上させることができる。しかも上記4種の金属元素はAlと化合して0．1～0．5μm程度の微細な析出物を形成することにより強度の向上にも寄与する。但し含有量が少な過ぎると靭性及び強度に対する向上効果が充分でなく、含有量が多過ぎると粗大な晶出物を形成し、靭性を低下させてしまう。従ってCr量は0．05～0．3%，Mn量は0．05～0．8%，Zr量は0．05～0．3%，Ti量は0．03～0．3%の範囲内とすることが必要である。

【0012】尚Crの下限としては、より好ましくは0．08%以上、更に好ましくは0．1%以上、一方上限は好ましくは0．25%以下、更に好ましくは0．2%以下である。Mnの下限としては、より好ましくは0．1%以上、更に好ましくは0．2%以上、一方上限は好ましくは0．6%以下、更に好ましくは0．5%以下である。

【0013】Zrの下限としては、より好ましくは0．08%以上、更に好ましくは0．1%以上、一方上限は好ましくは0．25%以下、更に好ましくは0．2%以下である。またTiの下限としては、より好ましくは0．05%以上、更に好ましくは0．07%以上、一方上限は好ましくは0．2%以下、更に好ましくは0．15%以下である。

【0014】Fe：1．0%以下（0%を含まない）

Si：1．0%以下（0%を含まない）

Fe及びSiはAl精錬時に残存する不可避不純物であり、不溶性化合物を形成することから、一般的に言ってAl合金にとって望ましくない元素であり、通常は極力制限される。本発明ではFe量及びSi量ともに1．0%まで許容できるものの、1．0%を超えると不溶性化合物が粗大かつ多量に形成され、靭性が著しく低下する。

【0015】本発明に係るAl－Cu－Mg系合金においては、Fe及びSiを含む不溶性化合物粒の最大長さ及びその体積分率を制御することが高い靭性を得る上で非常に重要である。上記不溶性化合物粒の最大長さが2μm以下、かつその体積分率が2．0%以下である場合には、圧延加工後のST方向にも優れた靭性を発揮する。上記不溶性化合物粒の最大長さは、高靭性を得る上で1．5μm以下が望ましく、1．0μm以下がより好ましい。一方不溶性化合物の体積分率は1．5%以下が好ましく、1．0%以下であればより望ましい。

【0016】上記不溶性化合物粒の最大長さとは、例えば球状や円盤状の結晶であれば最大直径を与える様な切断面を形成した時の最大直径であり、また略立方体や略直方体の結晶であれば最も長い対角線の長さを指し、不

特定な形状の結晶であれば最も離れた表面上の２点間の長さを言う。尚上記不溶性化合物粒の最大長さを測定するにあたっては、電子顕微鏡を用い顕微鏡視野で算出すればよい。

【００１７】上記不溶性化合物粒の最大長さ及び体積分率を制御するには、上記成分組成の要件を満足するＡｌ合金を用いると共に、凝固時の冷却速度Ｒが下記（１），（２）式

Ｒ≧５……（１）で且つ

Ｒ≧７．５（［Ｆｅ］＋［Ｓｉ］）＋２……（２）

但し、Ｒ：凝固時の冷却速度（℃／ｓｅｃ）

［Ｆｅ］，［Ｓｉ］：Ａｌ合金中のＦｅ、Ｓｉの含有率（％）

を満足する条件で連続鋳造を行なうことが重要である。

【００１８】即ち本発明のＡｌ合金では、連続鋳造法により凝固時に速やかに冷却してＦｅやＳｉなどの不可避不純物元素を強制固溶させ、靭性に悪影響を及ぼす不溶性化合物の大きさ及び量を制限しようというものであり、上記条件を満足すればＦｅ及びＳｉを含有する不溶性化合物粒の最大長さ２μm以下、体積分率を２％以下に制御できる。一方凝固時の冷却速度が前記条件を満足しない場合には、ＦｅやＳｉという不純物元素を十分に強制固溶させることができずに、Ｆｅ及びＳｉを含む不溶性化合物粒の最大長さ及びその体積分率を本発明範囲内に制御できず、十分な靭性を得ることはできない。

【００１９】前述の通り上記条件式（１），（２）で示される推奨範囲は、［Ｆｅ］＋［Ｓｉ］の値が０．４％以下のときは（１）式によって、また［Ｆｅ］＋［Ｓｉ］の値が０．４％超のときは（２）式によって規定されることを意味する。この様に本発明に係るＡｌ合金を製造するにあたりＦｅやＳｉなどの不可避不純物元素の含有量が多い場合には、その含有量に応じて連続鋳造過程における凝固時の冷却速度を増加させ、不溶性化合物粒の最大長さ及び体積分率を制御することが望ましい。

【００２０】尚本発明のＡｌ合金は、前記成分組成成のＡｌ合金を用いて特定条件による冷却速度で連続鋳造を行い、Ｆｅ及びＳｉを含有する不溶性化合物粒の最大長さ及び体積分率を制御することにより優れた靭性を得られるものであり、その他の製造条件については特に制限されるものではないが、以下の製造方法が例示できる。

【００２１】まず本発明に係る合金組成を有するＡｌ合金を溶融体とし、この溶融体を連続鋳造する。連続鋳造法としては、水冷式連続鋳造法、双ロール式連続鋳造法、ベルト式連続鋳造法、ブロック式連続鋳造法などを採用することができるが、連続鋳造から熱間圧延工程への移行時期は、鋳片内部が固相線温度以下にまで低下して完全に凝固した後にタイミングを合わせるのが好ましい。

【００２２】本発明は、連続鋳造して得られる移動帯板の温度を熱間圧延温度以上に保持して直ちに熱間圧延し、引き続いて、若しくは一旦巻き取ってから冷間圧延工程へ送る所謂連鋳・直送圧延方法に有利に適用されるが、この他連続鋳造の後、一旦保持し、鋳片温度が実質的に降下しないうちに熱間圧延へ送り、更に冷間圧延を行なう方法にも適用することができる。

【００２３】尚熱間圧延を施す場合、開始温度は４５０～５００℃の範囲が好ましく、３００～３５０℃の仕上げ温度で終了することが望ましい。連続鋳造法では通常４～３０mm程度の肉厚の移動帯板が連続的に製造され、これを熱間圧延し、更に必要に応じて冷間圧延を行うことによって、０．７～２０mm程度の肉厚のＡｌ合金板に圧延される。圧下率としては３０％以上が好ましい。

【００２４】熱間圧延または熱間圧延及び冷間圧延を施したＡｌ合金板は、溶体化処理の後水焼き入れし、さらに時効処理を施す。上記溶体化処理の条件としては処理温度が４５０～５２０℃、処理時間は１～６時間が望ましい。時効処理の条件としては１６０～２００℃の時効温度で８～２４時間が好ましい。

【００２５】

【実施例】

実施例１～１５

表１に示す組成のＡｌ合金を溶融体とし、連続鋳造法により肉厚２０mmの移動帯板を作製し、直ちに熱間圧延を施し肉厚５mmの板材とした。尚連続鋳造時の冷却速度は１２℃／ｓｅｃであり、上記熱間圧延の圧延開始温度は４５０℃、、終了温度は３５０℃であった。上記板材に５００℃で４時間の溶体化処理を施して水焼き入れを行ない、１８０℃で２４時間の時効処理を行なった。

【００２６】この様にして得たＡｌ合金板について、走査型電子顕微鏡観察と画像解析を行なうことによって不溶性化合物粒の最大長さ及び体積分率を求めると共に、ＳＴ方向の破壊靭性試験を行なった。さらに引張試験で耐力を測定して強度の評価を行なった。結果は表１に併記する。

【００２７】比較例１～１５

表２に示す組成のＡｌ合金溶湯を用いて、後述の条件以外は実施例と同様にしてＡｌ合金板を得た。走査型電子顕微鏡観察と画像解析を行なうことによって不溶性化合物粒の最大長さ及び体積分率を求めると共に、ＳＴ方向の破壊靭性試験を行なった。さらに引張試験で耐力を測定して強度の評価を行なった。結果は表２に併記する。

【００２８】尚比較例１，２のＡｌ合金板は、連続鋳造時の冷却速度を３℃／ｓｅｃとした以外は実施例と同様にして得たものであり、比較例３～１３のＡｌ合金板は、本発明に係る合金組成のうち少なくとも１種の元素において条件を満足しておらず、比較例１４，１５は従来合金を用い通常の鋳造法（冷却速度１℃／ｓｅｃ）で作製したものである。

【００２９】これら比較用のＡｌ合金板について、走査

型電子顕微鏡観察と画像解析を行なうことによって不溶性化合物粒の最大長さ及び体積分率を求めると共に、ST方向の破壊靭性試験を行なった。さらに引張試験で耐力を測定して強度の評価を行なった。結果は表2に併記＊＊する。

【0030】

【表1】

実施例 No.	合金組成（重量%） Cu	Mg	Cr	Mn	Zr	Ti	Fe	Si	不溶性化合物 大きさ（μm）	体積分率（%）	破壊靭性 K_IC (*1)	判定	強度 耐力 (MPa)	判定
1	4.0	1.5	0.1	0.4	0.1	0.1	0.5	0.3	1.0	1.0	100	○	400	○
2	4.0	1.5	0.1	0.4	0.1	0.1	0.5	0.3	0.8	0.5	110	○	400	○
3	2.5	0.8	0.1	0.2	－	－	0.3	0.2	1.0	1.0	110	○	350	○
4	2.0	0.8	0.1	0.2	－	－	0.3	0.2	1.0	1.0	110	○	340	○
5	7.0	1.0	0.05	0.05	0.05	0.03	0.2	0.2	0.9	0.6	105	○	360	○
6	3.5	0.2	0.1	0.1	－	－	1.0	0.2	1.5	2.0	90	○	330	○
7	3.5	0.5	0.2	0.2	－	－	0.3	1.0	2.0	1.3	90	○	340	○
8	3.5	1.0	0.3	0.2	－	－	0.5	0.5	1.2	1.0	110	○	370	○
9	3.5	1.7	0.1	0.8	0.05	0.05	0.3	0.2	1.5	1.5	100	○	390	○
10	3.5	2.0	0.1	0.1	0.3	0.3	0.2	0.1	1.0	0.8	110	○	400	○
11	3.5	2.5	0.2	0.2	0.2	0.2	0.5	0.3	1.0	1.0	100	○	410	○
12	5.5	1.0	0.2	0.3	0.1	－	0.8	0.2	1.5	1.5	95	○	410	○
13	5.5	1.0	0.2	0.3	0.1	－	0.6	0.4	1.5	1.5	100	○	410	○
14	5.5	1.0	0.2	0.3	0.1	－	0.4	0.6	1.5	1.5	100	○	410	○
15	5.5	1.0	0.2	0.3	0.1	－	0.2	0.8	1.5	1.5	90	○	410	○

(*1)：$kg \cdot mm^{-3/2}$

【0031】 ※ ※【表2】

比較例 No.	合金組成（重量%） Cu	Mg	Cr	Mn	Zr	Ti	Fe	Si	不溶性化合物 大きさ（μm）	体積分率（%）	破壊靭性 K_IC (*1)	判定	強度 耐力 (MPa)	判定
1	4.0	1.5	0.1	0.4	0.1	0.1	0.5	0.3	3	1.0	80	×	400	○
2	4.0	1.5	0.1	0.4	0.1	0.1	0.5	0.3	2	3.0	70	×	400	○
3	1.0	1.5	0.1	0.4	0.1	0.1	0.5	0.3	1	1.0	100	○	320	×
4	8.0	1.5	0.1	0.4	0.1	0.1	0.5	0.3	1	1.0	60	×	410	○
5	4.0	0.1	0.1	0.4	0.1	0.1	0.5	0.3	1	1.0	100	○	300	×
6	4.0	3.0	0.1	0.4	0.1	0.1	0.5	0.3	3	1.0	70	×	400	○
7	4.0	1.5	0.03	0.03	0.03	0.01	0.5	0.3	1	1.0	60	×	380	○
8	4.0	1.5	0.4	0.4	0.1	0.1	0.5	0.3	3	3.0	80	×	400	○
9	4.0	1.5	0.1	1.0	0.1	0.1	0.5	0.3	3	3.0	70	×	410	○
10	4.0	1.5	0.1	0.4	0.4	0.1	0.5	0.3	3	3.0	80	×	400	○
11	4.0	1.5	0.1	0.4	0.1	0.4	0.5	0.3	3	3.0	60	×	400	○
12	4.0	1.5	0.1	0.4	0.1	0.1	1.2	0.3	5	3.0	50	×	410	○
13	4.0	1.5	0.1	0.4	0.1	0.1	0.5	1.2	5	3.0	50	×	390	○
14	4.8	1.8	0.1	0.8	0.1	0.1	0.5	0.5	3	3.0	70	×	380	○
15	4.5	0.8	0.1	1.0	0.1	0.1	0.7	0.8	3	3.0	80	×	320	×

(*1)：$kg \cdot mm^{-3/2}$

【0032】表1から明らかな様に本発明に係るAl合金は、不溶性化合物粒の最大長さが2μm以下で、しかも体積分率が2％以下であることから圧延加工後のST方向の靭性も高く、かつ高強度であることが分かる。また表2に明らかな通り、本発明に係る条件のいずれかを満たさない比較例は、靭性または強度において充分ではない。

【0033】比較例においてNo. 1，2は連続鋳造条件が異なるもので、No. 1は不溶性化合物粒の最大長さが2μmを超え、No. 2は不溶性化合物の体積分率が2％を超えることから、夫々破壊靭性が低い。No. 3はCu量が少な過ぎる場合の比較例、No. 5はMg量が少な過ぎる場合の比較例であり、共に強度が著しく低い。No. 4はCu量が多過ぎる場合の比較例、No. 6はMg量が多過ぎる場合の比較例であり、不溶性化合物粒の最大長さが2μmを超えて粗大であり、靭性が著しく低い。No. 7はCr，Mn，Zr及びTiの量がいずれも少な過ぎる場合の比較例であり、靭性に劣る。No. 8～11は

Ｃｒ，Ｍｎ，Ｚｒ及びＴｉのうち、いずれかの量が多過ぎる場合の比較例であり、不溶性化合物粒の最大長さが２μｍを超えると共に体積分率も２％を超えており、靭性が著しく低い。No.１２，１３は不可避不純物であるＦｅまたはＳｉの量が多過ぎる場合の比較例であり、靭性に乏しい。No.１４，１５は従来のＡｌ合金であり、不溶性化合物粒の最大長さ及び体積分率が本発明の範囲を超えており、靭性に劣り、しかもNo.１５は強度も乏しい。

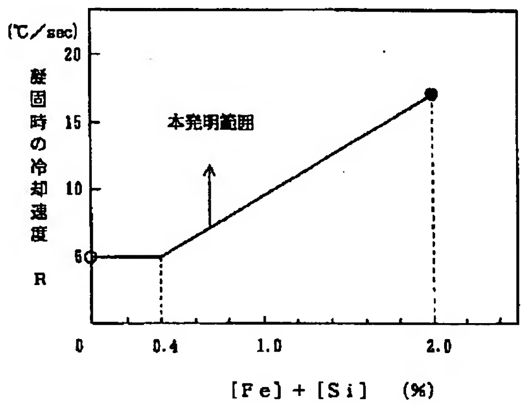
【００３４】

【発明の効果】本発明は以上の様に構成されており、連続鋳造法によりＡｌ－Ｃｕ－Ｍｇ系合金中における不溶性化合物粒の最大長さを２μｍ以下とし、しかもその体積分率を２％以下に制御しているので、Ａｌ－Ｃｕ－Ｍｇ系合金の高強度という特性に加えて、その靭性も向上させることができ、靭性に優れたＡｌ－Ｃｕ－Ｍｇ系合金及びその製造方法が提供できることとなった。

【図面の簡単な説明】

【図１】本発明の製造方法において用いられる連続鋳造時の好ましい冷却速度条件を示すグラフである。

【図1】



* NOTICES *

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(51) [International Patent Classification (6th Edition)]

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[Translation done.]

Epitome

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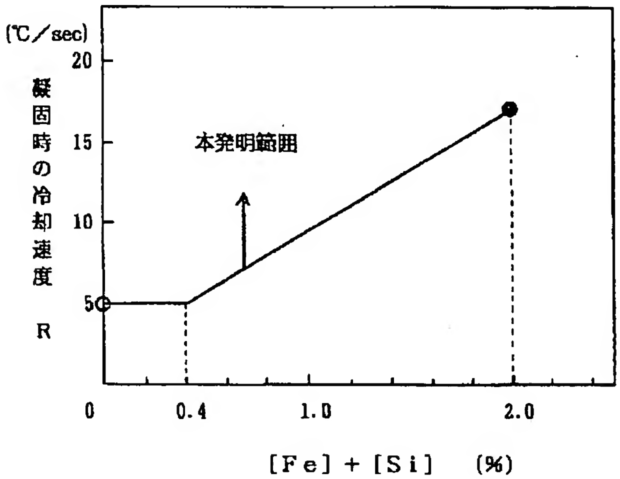
(57) [Abstract]
[Objects of the Invention] It is the high intensity aluminum alloy suitable as an object for structural members with which high intensity is demanded in the aircraft, a rail car, sporting goods, etc., and aluminum alloy which was moreover excellent in toughness, and its manufacture approach are offered.
[Elements of the Invention] Cu: 2-7%, Mg:0.2-2.5%, less than [Fe:1.0%], less than [Si:1.0%], And one or more sorts chosen from the group which consists of Cr, Mn, Zr, and Ti are contained by Cr:0.05-0.3%, Mn:0.05-0.8%, Zr:0.05-0.3%, and Ti:0.03-0.3% of within the limits, respectively. It heat-treats, while performing rolling between continuous casting post heating or performing hot rolling and cold rolling in aluminum alloy with which the remainder consists of aluminum and an unescapable impurity. The aluminum-Cu-Mg system alloy which the maximum length of the insoluble compound grain containing Fe and Si was controlled by 2 micrometers or less, and was controlled to 2.0% or less in the volume fraction is indicated.

[Translation done.]



[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] Cu: 2-7% (unless % of the weight is meant and mentioned specially, it is below the same)
Mg: Less than [0.2-2.5%Fe:1.0%] (0% is not included)
Si: Less than [1.0%] (0% is not included)
One or more sorts chosen from the group which fills ****** and consists of Cr, Mn, Zr, and Ti are contained by Cr:0.05-0.3%Mn:0.05-0.8%Zr:0.05-0.3%Ti:0.03-0.3% of within the limits, respectively. It heat-treats, while performing rolling between continuous casting post heating or performing hot rolling and cold rolling in aluminum alloy with

which the remainder consists of aluminum and an unescapable impurity. The aluminum-Cu-Mg system alloy excellent in the toughness characterized by controlling the maximum length of the insoluble compound grain containing Fe and Si to 2 micrometers or less, and coming to control a volume fraction to 2.0% or less.

[Claim 2] In manufacturing an aluminum-Cu-Mg system alloy according to claim 1, the cooling rate R at the time of coagulation is R>=5, and they are R>=7.5 ([Fe]+ [Si])+2, however a cooling rate at the time of R:coagulation (degree C/sec).

Fe in a [Fe] [Si]:aluminum alloy, content of Si (%)

The manufacture approach of an aluminum-Cu-Mg system alloy excellent in the toughness characterized by holding this cast piece temperature beyond hot rolling temperature, and hot-rolling it after carrying out continuous casting on the conditions to satisfy.

[Claim 3] The manufacture approach according to claim 2 of sending immediately the migration strip by which continuous casting was carried out to a hot rolling process.

[Claim 4] The manufacture approach according to claim 2 of adjusting the cast piece by which continuous casting was carried out to hot rolling temperature, and sending it to a hot rolling process.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] About the aluminum-Cu-Mg system alloy excellent in toughness, and its manufacture approach, this invention is a high intensity aluminum alloy suitable as an object for structural members as which high intensity is required in the aircraft, a rail car, sporting goods, etc. for a detail, and relates to aluminum alloy which was

moreover excellent in toughness, and its manufacture approach.
[0002]
[Description of the Prior Art] As a typical high intensity aluminum alloy, the aluminum-Cu-Mg system alloy is known in the name of duralumin, and 2014 alloys of JIS, 2017 alloys, 2024 alloys, etc. are developed. In addition, when the high intensity property of the above-mentioned aluminum-Cu-Mg system alloy is acquired by the age-hardening and manufactures this, its method of casting an ingot first, homogenizing if needed, forging enough at an elevated temperature, removing cast structure, carrying out quenching after solution treatment further, and performing aging treatment is common.
[0003] However, said aluminum-Cu-Mg system alloy has low toughness, and the toughness of the direction of board thickness after cold-working termination between heat (the direction of ST) has especially the problem of being sharply low, compared with the processing direction (the direction of L), or the cross direction (the direction of LL). It originates in the distraction of this being carried out in the processing direction, it standing in a row, and the insoluble compound in an alloy committing it as a sharp notch. In addition, the above-mentioned insoluble compound is a compound containing impurities which remain at the time of aluminum refinement, such as Fe and Si, and even if it makes high processing temperature in homogenization or solution treatment, it is a compound which does not dissolve in an alloy but is crystallized granular.
[0004] How to restrict the content of impurity elements, such as Fe and Si, leading to said insoluble compound as much as possible as a means to improve the toughness of such an aluminum-Cu-Mg system alloy can be considered. For example, the approach of the amount of Si limiting Fe which is an impurity to JP,55-47371,A 0.15% or less, and limiting Si to 0.1% or less, although the amount of Fe(s) of said 2014 alloys is prescribed to 0.5 - 1.2% by JIS 0.7% or less is indicated. However, it needs to restrict the content of Fe and Si which are an unescapable impurity as much as possible, i.e., aluminum metal with very high purity, it becomes cost quantity, and is lacking in practicality.
[0005]
[Problem(s) to be Solved by the Invention] This invention is made paying attention to the above-mentioned situation, and even if the content of Fe or Si which is an unescapable impurity is comparable as the former, it tends to offer the aluminum-Cu-Mg system alloy which was excellent in toughness also in the direction of ST after strip processing, and its manufacture approach by improving the manufacture approach.
[0006]
[Means for Solving the Problem] The aluminum-Cu-Mg system alloy concerning this invention which was able to solve the above-mentioned technical problem is less than

[Cu:2-7%Mg:0.2-2.5%Fe:1.0%] (0% is not included).
Si: Less than [1.0%] (0% is not included)
One or more sorts chosen from the group which fills ****** and consists of Cr, Mn, Zr, and Ti are contained by Cr:0.05-0.3%Mn:0.05-0.8%Zr:0.05-0.3%Ti:0.03-0.3% of within the limits, respectively. It heat-treats, while performing rolling between continuous casting post heating or performing hot rolling and cold rolling in aluminum alloy with which the remainder consists of aluminum and an unescapable impurity. Let it be a summary to control the maximum length of the insoluble compound grain containing Fe and Si to 2 micrometers or less, and to come to control a volume fraction to 2.0% or less.

[0007] And for this invention, as one of the suitable means for manufacturing the above-mentioned aluminum-Cu-Mg system alloy, the cooling rate R at the time of coagulation is R>=5.... (1)
R>=7.5 ([Fe]+ [Si])+2 .... (2)
However, R: The cooling rate at the time of coagulation (degree C/sec)
Fe in a [Fe] [Si]:aluminum alloy, content of Si (%)
the condition of having held this cast piece beyond hot rolling temperature after carrying out continuous casting on the conditions to satisfy -- immediately -- or the approach of hot-rolling, after adjusting to hot rolling temperature is offered. In addition, it means that are prescribed by (1) type when the value of [Fe]+ [Si] is 0.4% or less, as the recommendation range shown by the above-mentioned conditional expression (1) and (2) is shown in drawing 1 , and the value of [Fe]+ [Si] is specified by (2) types at the time of 0.4% super-**.

[0008]
[Function] As a result of repeating research wholeheartedly about the technical problem that this invention persons raise the toughness of an aluminum-Cu-Mg system alloy, even if it is the aluminum-Cu-Mg system alloy which contained Fe and Si to some extent even if In what is 2 micrometers or less about the maximum length of the insoluble compound grain which is made to carry out forcible dissolution of Fe and the Si into an alloy by continuous casting, and contains Fe and Si, and moreover controlled the volume fraction to 2% or less Knowledge that the toughness of the direction of ST after strip processing can also be raised was acquired without spoiling reinforcement. In order to control the length between couplings and the volume fraction of the above-mentioned insoluble compound grain furthermore, it traced that it was the best approach to control the cooling rate at the time of the coagulation in a continuous casting process in a fixed condition, and to carry out forcible dissolution of Fe and the Si into an alloy, and this invention was completed. The reason for limitation of the component

presentation first applied to this invention is explained below.

[0009] Cu:2 - 7%Mg: -- Cu and Mg are elements which form a detailed sludge 1 micrometer or less called aluminum2 CuMg, and are greatly contributed to improvement in reinforcement 0.2 to 2.5%. The maximum length of the insoluble compound grain containing Fe and Si will serve as a big and rough crystallization object exceeding 2 micrometers, and the amount of Cu(s) will reduce toughness, if reinforcement with less than 2% or the amount of Mg sufficient at less than 0.2% is not obtained, the amount of Cu(s) exceeds 7% on the other hand or the amount of Mg exceeds 2.5%. Therefore, as for the amount of Cu(s), 2 - 7% and the amount of Mg need to be 0.2 - 2.5%.

[0010] In addition, on the other hand as a minimum of Cu, an upper limit is 5.5% or less still more preferably 6.5% or less preferably 3.5% or more still more preferably 2.5% or more. Moreover, on the other hand as a minimum of Mg, an upper limit is 1.7% or less still more preferably 2.0% or less preferably 1.0% or more still more preferably 0.5% or more.

[0011] Cr: By making one or more of the four above-mentioned sorts of metallic elements contain within the limits of the above in aluminum alloy of this invention 0.05 - 0.3%Mn:0.05 - 0.8%Zr:0.05 - 0.3%Ti:0.03 to 0.3%, crystal grain of aluminum alloy can be made detailed and toughness can be raised. And the four above-mentioned sorts of metallic elements contribute also to improvement in reinforcement by combining with aluminum and forming an about 0.1-0.5-micrometer detailed sludge. However, if the improvement effectiveness over toughness and reinforcement is not enough if there are too few contents, and there are too many contents, a big and rough crystallization object will be formed and toughness will be reduced. Therefore, as for the amount of Cr(s), the amount of Mn requires that the amount of Zr should make 0.05 - 0.3%, and the amount of Ti 0.03 - 0.3% of within the limits 0.05 to 0.8% 0.05 to 0.3%.

[0012] In addition, on the other hand as a minimum of Cr, an upper limit is 0.2% or less still more preferably 0.25% or less preferably 0.1% or more still more preferably 0.08% or more. On the other hand as a minimum of Mn, an upper limit is 0.5% or less still more preferably 0.6% or less preferably 0.2% or more still more preferably 0.1% or more.

[0013] On the other hand as a minimum of Zr, an upper limit is 0.2% or less still more preferably 0.25% or less preferably 0.1% or more still more preferably 0.08% or more. Moreover, on the other hand as a minimum of Ti, an upper limit is 0.15% or less still more preferably 0.2% or less preferably 0.07% or more still more preferably 0.05% or more.

[0014] Fe: Less than [1.0%] (0% is not included)

Si: Less than [1.0%] (0% is not included)

Fe and Si are unescapable impurities which remain at the time of aluminum refinement,

since they form an insoluble compound, generally, for aluminum alloy, are an element which is not desirable and are usually restricted as much as possible. In this invention, although the amount of Fe(s) and the amount of Si are permissible to 1.0%, if it exceeds 1.0%, it will be formed big and rough [an insoluble compound] and so much, and toughness will fall remarkably.

[0015] In the aluminum-Cu-Mg system alloy concerning this invention, when controlling the length between couplings of the insoluble compound grain containing Fe and Si and its volume fraction acquires high toughness, it is very important. When the maximum length of the above-mentioned insoluble compound grain is 2 micrometers or less and the volume fraction is 2.0% or less, the toughness which was excellent also in the direction of ST after strip processing is demonstrated. The maximum length of the above-mentioned insoluble compound grain has desirable 1.5 micrometers or less, when acquiring high toughness, and its 1.0 micrometers or less are more desirable. On the other hand, the volume fraction of an insoluble compound is desirable, and if it is 1.0% or less, it is more desirable. [1.5% or less of]

[0016] the above-mentioned insoluble compound grain -- maximum length -- **** -- for example, if it is a diameter at the maximum equator when forming a cutting plane which gives a diameter at the maximum equator if it is the shape of a ball, and a disc-like crystal, and it is the crystal of an abbreviation cube or an abbreviation rectangular parallelepiped, the die length of the longest diagonal line will be pointed out, and if it is the crystal of an unspecified configuration, the die length between two on the most distant front face will be said. In addition, what is necessary is just to compute by the microscopic field using an electron microscope, if in charge of measuring the maximum length of the above-mentioned insoluble compound grain.

[0017] the above-mentioned insoluble compound grain -- maximum length -- and -- in order to control a volume fraction, while using aluminum alloy with which are satisfied of the requirements for the above-mentioned component presentation -- the cooling rate R at the time of coagulation -- the (following 1) and following (2) type R>=5 .... (1) -- R>=7.5 ([Fe]+ [Si])+2 [and] .. (2)

However, R: The cooling rate at the time of coagulation (degree C/sec)

Fe in a [Fe] [Si]:aluminum alloy, content of Si (%)

It is important to perform continuous casting on the conditions to satisfy.

[0018] That is, it cools promptly by the continuous casting process at the time of coagulation, forcible dissolution of the unescapable impurity elements, such as Fe and Si, is carried out, and it says that the magnitude and the amount of an insoluble compound which have a bad influence on toughness will be restricted, and if the above-mentioned conditions are satisfied, 2 micrometers or less and a volume fraction are

controllable [to 2% or less] by aluminum alloy of this invention in the maximum length of the insoluble compound grain containing Fe and Si. On the other hand, when the cooling rate at the time of coagulation does not satisfy said conditions, the length between couplings of the insoluble compound grain containing Fe and Si and its volume fraction cannot be controlled to this invention within the limits, without the ability fully carrying out forcible dissolution of an impurity element called Fe and Si, and sufficient toughness cannot be acquired.

[0019] It means that the recommendation range shown by the above-mentioned conditional expression (1) and (2) as above-mentioned is prescribed by (1) type when the value of [Fe]+ [Si] is 0.4% or less, and the value of [Fe]+ [Si] is specified by (2) types at the time of 0.4% super-**. Thus, in manufacturing aluminum alloy concerning this invention, when there are many contents of unescapable impurity elements, such as Fe and Si, it is desirable to make the cooling rate at the time of the coagulation in a continuous casting process increase according to that content, and to control the length between couplings and the volume fraction of an insoluble compound grain.

[0020] In addition, although aluminum alloy of this invention performs continuous casting with the cooling rate by specific conditions using aluminum alloy of said component ******, cannot acquire the toughness which was excellent by controlling the length between couplings and the volume fraction containing Fe and Si of an insoluble compound grain and is not restricted especially about other manufacture conditions, it can illustrate the following manufacture approaches.

[0021] aluminum alloy which has the alloy presentation first applied to this invention is used as a melting object, and continuous casting of this melting object is carried out. As a continuous casting process, although a water cooling type continuous casting process, a congruence roll type continuous casting process, a belt type continuous casting process, a block system continuous casting process, etc. are employable, after the interior of a cast piece falls below to solidus-line temperature and solidifies completely the shift stage from continuous casting to a hot rolling process, it is desirable to double timing.

[0022] Before it once holds after continuous casting although applied in favor of the so-called continuous casting sent to a cold rolling process once hold the temperature of the migration strip obtained by carrying out continuous casting of this invention beyond hot rolling temperature, it hot-rolls immediately, and it continues or it rolls round, and the direct delivery rolling approach, and descending substantially [cast piece temperature], it is applicable to hot rolling also at delivery and the approach of cold-rolling further.

[0023] In addition, when hot-rolling, initiation temperature has the desirable range of 450-500 degrees C, and it is desirable to end by the finishing temperature which is 300-

350 degrees C. In a continuous casting process, when an about 4-30mm thick migration strip is manufactured continuously, hot-rolls this and usually cold-rolls if needed further, about 0.7-20mm thick aluminum alloy plate rolls out. As rolling reduction, 30% or more is desirable.

[0024] Solution treatment carries out after water quenching of the aluminum alloy plate which performed hot rolling or hot rolling, and cold rolling, and it performs aging treatment further. As conditions for the above-mentioned solution treatment, 1 - 6 hours has [450-520 degrees C and the processing time] desirable processing temperature. As conditions for aging treatment, 8 - 24 hours is desirable at the aging temperature of 160-200 degrees C.

[0025]

[Example]

aluminum alloy of the presentation shown in one to example 15 table 1 was used as the melting object, and the migration strip with a thickness of 20mm was produced by the continuous casting process, and it hot-rolled immediately, and considered as the plate with a thickness of 5mm. In addition, the cooling rate at the time of continuous casting was 12 degrees C/sec, the rolling initiation temperature of the above-mentioned hot rolling was 450 degrees C, and termination temperature was 350 degrees C. Solution treatment of 4 hours was performed to the above-mentioned plate at 500 degrees C, water quenching was performed, and aging treatment of 24 hours was performed at 180 degrees C.

[0026] Thus, while asking for the length between couplings and the volume fraction of an insoluble compound grain by performing scanning electron microscope observation and image analysis about obtained aluminum alloy plate, the fracture toughness test of the direction of ST was performed. Furthermore, proof stress was measured by the tension test, and reinforcement was evaluated. A result is written together to Table 1.

[0027] aluminum alloy plate was obtained like the example using aluminum alloy molten metal of the presentation shown in one to example of comparison 15 table 2 except the below-mentioned conditions. While asking for the length between couplings and the volume fraction of an insoluble compound grain by performing scanning electron microscope observation and image analysis, the fracture toughness test of the direction of ST was performed. Furthermore, proof stress was measured by the tension test, and reinforcement was evaluated. A result is written together to Table 2.

[0028] In addition, aluminum alloy plate of the examples 1 and 2 of a comparison is obtained like an example except having set the cooling rate at the time of continuous casting to 3 degrees C/sec, and aluminum alloy plate of the examples 3-13 of a comparison does not satisfy conditions in at least one sort of elements among the alloy

presentations concerning this invention, but the examples 14 and 15 of a comparison are conventionally produced with the usual casting (the cooling rate of 1 degree C / sec) using an alloy.

[0029] While asking for the length between couplings and the volume fraction of an insoluble compound grain by performing scanning electron microscope observation and image analysis about aluminum alloy plate for these comparisons, the fracture toughness test of the direction of ST was performed. Furthermore, proof stress was measured by the tension test, and reinforcement was evaluated. A result is written together to Table 2.

[0030]

[Table 1]

実施例 No.	合金組成（重量%）								不溶性化合物		破壊靭性		強度	
	Cu	Mg	Cr	Mn	Zr	Ti	Fe	Si	大きさ (μm)	体積分率 (%)	K_{IC} (*1)	判定	耐力 (MPa)	判定
1	4.0	1.5	0.1	0.4	0.1	0.1	0.5	0.3	1.0	1.0	100	○	400	○
2	4.0	1.5	0.1	0.4	0.1	0.1	0.5	0.3	0.8	0.5	110	○	400	○
3	2.5	0.8	0.1	0.2	—	—	0.3	0.2	1.0	1.0	110	○	350	○
4	2.0	0.8	0.1	0.2	—	—	0.3	0.2	1.0	1.0	110	○	340	○
5	7.0	1.0	0.05	0.05	0.05	0.03	0.2	0.2	0.9	0.6	105	○	360	○
6	3.5	0.2	0.1	0.1	—	—	1.0	0.2	1.5	2.0	90	○	330	○
7	3.5	0.5	0.2	0.2	—	—	0.3	1.0	2.0	1.3	90	○	340	○
8	3.5	1.0	0.3	0.2	—	—	0.5	0.5	1.2	1.0	110	○	370	○
9	3.5	1.7	0.1	0.8	0.05	0.05	0.3	0.2	1.5	1.5	100	○	390	○
10	3.5	2.0	0.1	0.1	0.3	0.3	0.2	0.1	1.0	0.8	110	○	400	○
11	3.5	2.5	0.2	0.2	0.2	0.2	0.5	0.3	1.0	1.0	100	○	410	○
12	5.5	1.0	0.2	0.3	0.1	—	0.8	0.2	1.5	1.5	95	○	410	○
13	5.5	1.0	0.2	0.3	0.1	—	0.6	0.4	1.5	1.5	100	○	410	○
14	5.5	1.0	0.2	0.3	0.1	—	0.4	0.6	1.5	1.5	100	○	410	○
15	5.5	1.0	0.2	0.3	0.1	—	0.2	0.8	1.5	1.5	90	○	410	○

(*1): $kg \cdot mm^{-3/2}$

[0031]

[Table 2]

比較例 No.	合金組成（重量%）								不溶性化合物		破壊靱性		強度	
	Cu	Mg	Cr	Mn	Zr	Ti	Fe	Si	大きさ (μm)	体積分率 (%)	K_{IC} (*1)	判定	耐力 (MPa)	判定
1	4.0	1.5	0.1	0.4	0.1	0.1	0.5	0.3	3	1.0	80	×	400	○
2	4.0	1.5	0.1	0.4	0.1	0.1	0.5	0.3	2	3.0	70	×	400	○
3	1.0	1.5	0.1	0.4	0.1	0.1	0.5	0.3	1	1.0	100	○	320	×
4	8.0	1.5	0.1	0.4	0.1	0.1	0.5	0.3	1	1.0	60	×	410	○
5	4.0	0.1	0.1	0.4	0.1	0.1	0.5	0.3	1	1.0	100	○	300	×
6	4.0	3.0	0.1	0.4	0.1	0.1	0.5	0.3	3	1.0	70	×	400	○
7	4.0	1.5	0.03	0.03	0.03	0.01	0.5	0.3	1	1.0	60	×	380	○
8	4.0	1.5	0.4	0.4	0.1	0.1	0.5	0.3	3	3.0	80	×	400	○
9	4.0	1.5	0.1	1.0	0.1	0.1	0.5	0.3	3	3.0	70	×	410	○
10	4.0	1.5	0.1	0.4	0.4	0.1	0.5	0.3	3	3.0	80	×	400	○
11	4.0	1.5	0.1	0.4	0.1	0.4	0.5	0.3	3	3.0	60	×	400	○
12	4.0	1.5	0.1	0.4	0.1	0.1	1.2	0.3	5	3.0	50	×	410	○
13	4.0	1.5	0.1	0.4	0.1	0.1	0.5	1.2	5	3.0	50	×	390	○
14	4.8	1.8	0.1	0.8	0.1	0.1	0.5	0.5	3	3.0	70	×	380	○
15	4.5	0.8	0.1	1.0	0.1	0.1	0.7	0.8	3	3.0	80	×	320	×

(*1): $kg \cdot mm^{-3/2}$

[0032] Since the maximum length of an insoluble compound grain is 2 micrometers or less and a volume fraction is moreover 2% or less, the toughness of the direction of ST after strip processing is also high [aluminum alloy concerning this invention], so that clearly from Table 1, and it turns out that it is high intensity. Moreover, the example of a comparison with which either of the conditions concerning this invention is not filled is not enough in toughness or reinforcement a passage clear to Table 2.

[0033] the example of a comparison -- setting -- No. -- as for 1 and 2, continuous casting conditions differ, the maximum length of an insoluble compound grain exceeds 2 micrometers, and, as for No.1, No.2 have low fracture toughness respectively from the volume fraction of an insoluble compound exceeding 2%. The example of a comparison when No.3 have too few amounts of Cu(s), and No.5 are the examples of a comparison when there are too few amounts of Mg, and both reinforcement is remarkably low. They are an example of a comparison when there are too many amounts of Mg, the example of a comparison when No.4 have too many amounts of Cu(s), and No.6 have the big and rough maximum length of an insoluble compound grain exceeding 2 micrometers, and its toughness is remarkably low. No.7 are an example of a comparison when there are too few each amounts of Cr, Mn, Zr, and Ti, and they are inferior to toughness. No.8-11 are an example of a comparison when there is too many one of amounts among Cr, Mn, Zr, and Ti, while the maximum length of an insoluble compound grain exceeds 2 micrometers, the volume fraction is also over 2%, and its toughness is remarkably low. No. -- 12 and 13 are the examples of a comparison when there are too many amounts of Fe or Si which is an unescapable impurity, and are lacking in

toughness. No. -- aluminum alloy of the former [15 / 14 and] -- it is -- an insoluble compound grain -- maximum length -- and the volume fraction has exceeded the range of this invention, it is inferior to toughness, and, moreover, No.15 are deficient also in reinforcement.

[0034]

[Effect of the Invention] Since this invention is constituted as mentioned above, the maximum length of the insoluble compound grain in an aluminum-Cu-Mg system alloy is set to 2 micrometers or less by the continuous casting process and the volume fraction is moreover controlled to 2% or less, in addition to the property of the high intensity of an aluminum-Cu-Mg system alloy, the toughness can also be raised and the aluminum-Cu-Mg system alloy excellent in toughness and its manufacture approach can be offered.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the graph which shows the desirable cooling rate conditions at the time of the continuous casting used in the manufacture approach of this invention.

[Translation done.]

* NOTICES *

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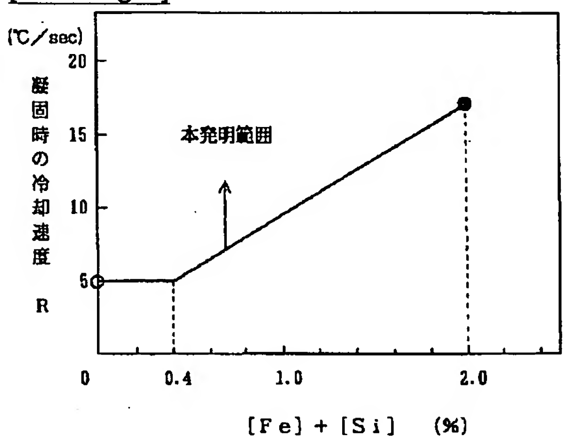
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

[Drawing 1]



[Translation done.]